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...OVISIONS FOR ELDERLY AND HANDICAPPED PEDESTRIANS

Vol. 1. Executive Summary

January 1979

Final Report

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FOREWORD

This report describes the investigation of the problems and hazards experienced by elderly and handicapped pedestrians. From these investigations, countermeasures were developed and field tested. Another product of this research is a manual for "Development of Priority Accessible Networks," (Implementation Package, FHWA-IP-79-6). This manual presents design information and methodology for creating a barrier free pedestrian facility.

Research in pedestrian safety is included in the Federally Coordinated Program of Highway Research and Development as Task 1 of Project 1E, "Safety of Pedestrians and Abutting Property Occupants." Mr. John C. Fegan is the Project Manager, Office of Research and Mr. Richard Richter is the Implementation Manager, Office of Development.

Sufficient copies of this report are being distributed to provide a minimum of three copies to each regional office, three copies to each division office and five copies for each State highway agency. Direct distribution is being made to the division offices.

Charles F. Scheffey
Director, Office of Research
Federal Highway Administration

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16. Abstract

Investigations were carried out in order to isolate the problems and hazards experienced by elderly and handicapped pedestrians, the results expressed in typological form, were prioritized; and some of the high priority environmental problems became the focus for later stages of the research.

Curb ramp criteria and tactile surface materials were evaluated and the results incorporated into countermeausures which were field tested.

The priority accessible network as a conceptual approach to barrier free urban areas has been developed; and a methodology for establishing the network is described.

This volume is the first of a series: the others are:

Vol. No.	FHWA No.	Short Title
2	79-2	Hazards, Barriers, Problems and the Law
3	79-3	The Development and Evaluation of Countermeasures
Implementation Package	79-6	A Manual for Developing a Priority Accessible Network

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the summary

introduction

The Problem

The elderly and handicapped have as much interest in moving freely around the city as the rest of the population. However, in most places and for many members of this group, travel along the sidewalks, the crosswalks, through the parks and all the other facilities of the city, is effectively barred by a variety of impediments.

The idea of an environment that is free from barriers in the sense that it is accessible to the handicapped as well as the rest of society, is now widely accepted. The Federal government and all of the states have legislation mandating some degree of accessibility.

The major thrust of changes directed at improving the environment from this point of view has been focused on making buildings accessible. Accessible towns do not yet exist, nor even accessible districts.

The pedestrian environment has evolved without sufficient attention given to the needs of people who are not young, able-bodied adults. It would seem that the sidewalks and paths and walkways, the crosswalks and parks were conceived by planners for the needs of some 'average' person--someone who is of 'normal' adult proportions, and who has 'normal' perceptual, mental, and physical capabilities. Obviously, this describes quite a small cross section of humankind. It excludes, by definition, children, those whose abilities are not 'normal'; and the elderly, whose abilities have deteriorated over time.

This very limited conception of the 'average' pedestrian is obviously not a conscious attempt to discriminate. Nor is it a callous disregard for others. It is simply that the urban policy makers and designers have, until recently, been unaware that their decisions cause problems. They have been unaware of the nature of the special needs of people other than 'normal' people.

These design failures are easier to understand when we examine the planning reference sources that are available to professionals, for these sources provide little assistance. In fact, there are no sources that treat the subject adequately. And this is not surprising because, before design recommendations can be set out, it is necessary to seek out the problems and then develop solutions that will work for the elderly and handicapped as well as the able bodied population.

An exacerbating factor is that the pedestrian environment is seldom planned. It usually occurs as an adjunct to some other planned activity--sidewalks and adjoining roads, walkways through plazas and parks, etc. The sidewalks and crosswalks are considered as necessary provisions for a successful vehicular traffic plan. But pedestrian traffic planning is almost non existent.

The Federal Highway Administration of the Department of Transportation in 1974 initiated a research study, "Provisions for Elderly and Handicapped Pedestrians," to examine the pedestrian environment, and to make proposals for improving accessibility. The Pedestrian Research Laboratory of Georgia Institute of Technology has carried out this contract and the work is described in a series of

technical reports. Volume 2 is divided into three parts. Part 1 is directed at identifying the major hazards experienced by the handicapped; the types of accidents that occur and what causes them, and how each of the handicapped groups is affected. Part 2 looks at the environmental barriers and problems. Field studies surveying the difficulties experienced by handicapped people are described, and a typology of barriers and problems is developed. Part 3 considers the federal and state legislation that covers access to the pedestrian environment.

Volume 3 deals with solutions to some of these problems. It describes laboratory and field tests which were carried out to evaluate some proposed solutions, and some from the study have been incorporated into The Implementation Package, "A Manual for Developing a Priority Accessible Network". The manual describes a planning process for systematically extending the accessible paths in an urban environment; and then provides recommended design solutions for many of the elements that cause difficulty for the handicapped pedestrian.

Classifications and Definitions.

As a first step to understanding the problems, it is necessary to identify the types of human condition that distinguish the elderly and handicapped from the designer's 'normal' person.

If we assume, as discussed earlier, that the pedestrian environment is intended for 'normal, healthy adults in their prime,' then these are people of 'normal stature and dimensions' with 'normal perceptions and reactions' with 'normal agility and stamina' and whose physical capabilities allowed them to cope with pedestrian activities with little difficulty. The remainder of the population is, therefore, by this definition, handicapped as pedestrians. Their dimensions, agility, reactions and bodily equipment are impaired or inadequately developed to operate as a pedestrian in the present environment without difficulty or greater than normal danger.

We can then specify the performance levels of the main physical and mental attributes necessary for 'normal pedestrian movement,' and conclude that unless the levels are reached, the subject is handicapped. We can classify them into the following handicapped groups relating to:

a. Developmental restrictions (size and maturity)

b. Chronic restrictive conditions related to agility, stamina, and reaction time

c. Lower extremity impairment (legs, feet)

d. Chronic impairment of upper extremities and shoulders (arms, shoulders and neck)

e. Severe auditory impairment

f. Severe visual impairment

g. Obvious confusion, and/or disorientation

Statistical information is available to enable us to further sub-divide those with lower extremity impairments into three groups, and those with developmental restrictions into two groups. Using this method, we have developed a classification of ten subgroups, as shown in Table 1.

Table 1. Typology of Handicapped Pedestrians

Handicap	Sub-Group	Est. Population 1975 (000)
Developmental restrictions (size and maturity)	1. Pre-school children	20,926
	2. School-age children	46,482
Chronic restrictive conditions related to agility, stamina, and reaction time	3. Persons over 65	22,170
Lower extremity impairment (legs, feet)	4. Confined to wheelchair	445
	5. Walking using special aids	5,042
	6. Walking with difficulty without the use of special aids	2,344
Chronic impairment of upper extremities and shoulders (arms, shoulders and neck)	7. Chronic impairment of upper extremities and shoulders	2,588
Severe auditory impairment	8. Severe auditory impairment	1,867
Severe visual impairment	9. Severe visual impairment	482
Obvious confusion, and/or disorientation	10. Obvious confusion and/or disorientation	20,000

From Table 1, the disabled population in 1975 (excluding children and the elderly) can thus be estimated as over 12 million. In percentage terms, the figure is of the order of 6 percent, and surprising as it may seem, it is apparent that one out of every 16 or 17 persons in the United States has a major handicap which acts as a deterrent to locomotion.

Further discussion on these data and categories can be found in Volume 2, "Hazards, Barriers, Problems and the Law" of this series.

environmental problems and barriers

The nature of the barriers and problems experienced by the elderly and handicapped within buildings has received considerable attention. But barriers in the exterior urban environment, on the other hand, are not so well understood.

Most of the published material, and even the standards and codes, have started with the assumption that the problems are known. None of the published studies have been directed at identifying and classifying the problems in a reasonably comprehensive manner. To remedy this, field studies were conducted in 5 U.S. cities; and these were directed at generating a typology and a listing of mobility problems.

In this investigation, data were collected from a representative sample of elderly and handicapped people, and from mobility instructors and others who work with them; in five cities in the United States that differ substantially in terms of climate, topography, socio-economic characteristics and regional location. The cities selected were Atlanta, Tampa/St. Petersburg, Chicago, San Francisco, and Seattle.

Methods Used

Three very different but complementary techniques were used for gathering the data in the field.

- Focused, but unstructured interviews with individuals.
- Panel discussions with groups of people who were elderly and handicapped or who work with them.
- Field observations using mobility tracking. In this method, the observers followed individual elderly and handicapped people as they moved around urban areas, and then recorded their responses to the environment and to known mobility barriers.

The focused interviews were used to obtain information based on the personal mobility experiences of elderly and handicapped individuals, and from the experiences of mobility instructors and others who work with the problems on a day-to-day basis. The panel discussions were used to generate discussion through the interaction of the participants, and by this means, to expand the exploration of the topics. The tracking studies were used to observe how elderly and handicapped people actually responded to the problems of the existing urban environment.

Findings

The cumulative results of the focused interview panel discussions and the tracking studies formed a listing of about 750 problem statements such as:

- There is often a small step at the bottom of curb ramps that prevents my wheelchair from traveling over them.

- I am afraid that I may bump against low overhanging projecting branches which I can't see.

This list of statements is not exhaustive, but it probably covers the most obvious of the problems experienced by elderly and handicapped pedestrians. The statements do not represent any sort of consensus. In fact, a problem may have been articulated by only one of the people interviewed.

Obviously, the investigation provides very limited evidence that these statements are true, and no evidence on the universality of these concerns. Nevertheless, they can be considered as plausible hypotheses for future evaluation, and their inclusion is necessary for an understanding of the overall problem.

The statements that fall within the scope of the study have been treated in one of several ways. If the stated problem seems to be self evident, with obvious and well known solutions, then the problem and recommended solutions have been presented in "A Manual for Developing a Priority Accessible Network". As an example of problems of this type we have:

- Snow and ice are frequently not cleared from the sidewalk.

No further research is needed to test the general validity of the comment, nor to establish that people in wheelchairs, and people on crutches particularly, are adversely affected by this condition.

The remaining statements can be divided into two types--those where the validity of the statement remains in doubt, and those where the statement is probably valid but the solutions are either unknown or are suspect. In both cases, further research is needed. However, the number of problems stated in this group is far more than could be treated within the financial and time constraints of the contract. It was therefore necessary to reduce the number to a manageable quantity.

Establishing Priorities

Several methods of selecting problems for further work were considered. One method that was rejected would have involved the development of a highly structured survey based on the statements. The survey would thus have provided a measure of the popularity of each statement included. This method was rejected, firstly, because of the time and expense constraints, and also because the results would have favored statements that affect the majority rather than the minorities. A problem that is unique to the visually impaired say, would be unlikely to be

popular with the whole target population because the visually impaired constitute a relatively small part of the population.

Finally, it was decided to make use of the opinion of a panel of experts to make a final selection of the problems to be dealt with further. The panel was chosen to include people who would represent each of the target subgroups. Each representative had the same disability as the members of his or her constituency, and was also an expert in mobility. The responsibility of each panel member therefore, was to speak not only for the group he or she represented, but also to help the group reach concensus.

Before the panel convened in Atlanta, the members were asked to help determine the extent to which each of the problem statements affected their constituencies. This was done in order to familiarize them with the statements and to aid them in forming their opinions as to which problems should be addressed. Each panel member was given a list of all of the problem statements and asked to answer two questions about each statement:

- What percentage of the people in your subgroup (blind, deaf, etc.) do you think are affected by this problem?

- How confident are you that your answer to the above is correct--expressed as a percentage?

For example, to the statement, "Ramps are difficult for me," the panel member who uses crutches answered as follows: "Seventy percent of those who use crutches would concur with the statement and I am 60% certain that my estimate is reliable."

After completing this task each panelist was asked to rank order a list of 18 problem areas--the problem areas being groupings of problem statements.

The overall rankings generated by the panelists are as follows:

1. Safer and easier ways to cross streets.

2. Provision for changing levels (non-mechanical).

3. Fire emergency provisions for the elderly and handicapped.

4. The design and location of mailboxes, parking meters, litter boxes, street lamp poles and signs, and other street furniture.

5. Signs and signal lights.

6. The problems at curbs, and curb ramp design.

7. Better location of cues for the visually handicapped.

8. The provision of toilet facilities, accessible to elderly and handicapped pedestrians using the streets.

9. Lighting and illumination at night.

10. The design of doors of all sorts.

11. The lack of places to rest in safety and comfort.

12. The design of elevators and their control system.

13. The design and provision of handrails and guardrails.

14. The design of materials used for walkways.

15. The design of escalators.

16. Parking and automobile access and egress problems.

17. The effects of street crime.

18. Congestion and crowding on walkways.

Again, the purpose of this task was to assist the panel members in formulating their views of the most urgent and the most important needs of their constituents. Not all of these statements fell within the scope of the project, but for this stage of the process, an overview of the whole list of problem statements was sought.

After completing these two tasks, the panelists were brought to Atlanta for a two day meeting. The goal of the meeting was to arrive at a consensus opinion in the form of a list of the most important problem areas that should be examined during the rest of the project. A second goal was to discuss these problem areas and to suggest possible countermeasures that could be evaluated.

At this stage, several of the previously ranked problem areas were removed from consideration because they were outside the scope of this study. They were:

- Fire emergency provisions
- Signs and signal lights
- The design of doors
- The design of elevators
- The design of escalators .

The panel agreed that all of the remaining problem areas should be considered further, with the greatest emphasis being placed on those with the higher rankings.

In the final phase of the work of the panel, a large number of potential

countermeasures were discussed and several of these were later developed for evaluation. These include:

- Design parameters for short ramps.
- Several different curb ramp layouts.
- The layout of street furniture to assist the blind.
- The use of surface textures to inform the blind.
- Restrictions in the right-turn-on-red rule in certain circumstances.
- Widened crosswalks.
- Accessible pedestrian islands on wide streets.
- A painted vehicular warning pattern for mid-block crossings.
- Extended sidewalks at certain intersections.
- Painted warnings to emphasize existing hazards such as manhole covers, and gratings.

In addition to environmental barriers and problems, elderly and handicapped pedestrians face very real dangers. The nature and causes of these hazards were considered as a next step.

environmental hazards

The pedestrian environment is not usually thought of as hostile (except perhaps in high crime areas). Most of us use corridors and sidewalks, pathways and crosswalks, parks and playgounds with little thought about the potential hazards. We tend to discount the dangers inherent in the physical environment because they are not sufficiently obvious or frequent and perhaps because we accept the risks.

Some of the hazards are well known and regularly recieve publicity in the media. It is quite well understood that pedestrians and vehicles cannot share common pavement space without some serious consequences. The magnitude of this problem on the other hand is probably not particularly generally known.

There are other hazards for the pedestrian which occur with much greater frequency and with equally serious consequences. For example, the overwhelming majority of serious pedestrian accidents do not involve motor vehicles. They are falls on the level and falls while changing level—on steps and stairs. The falls on the level are as a result of slips, trips, stumbles, falling into unguarded holes, etc. The falls on stairs can be attributed in part to the inherent dangers presented by stairs, in part because of poorly designed stairs, and in part from carelessness by the stair users.

There has been a substantial level of research activity into the nature and causes of pedestrian/vehicular accidents over the past few years. On the other hand, there has been little investigation of other types of pedestrian accidents.

To gain a better understanding of the particular hazards facing the target groups, two studies were undertaken. For the first study, an accident reporting section was included in the investigation carried out in five cities (and described earlier). This accident reporting section included vehicular and non-vehicular incidents. Concurrent with the 5 city investigation, a study of vehicular accidents involving elderly and handicapped pedestrians was carried out in Atlanta.

The Atlanta vehicular/pedestrian accident study

The objectives of the Atlanta accident study was to enlarge our understanding of the nature and causes of pedestrian accidents in which elderly and handicapped people are involved, and then to suggest some appropriate countermeasures. Specifically, the aim was to identify what types of accidents the target group experiences, and to what extent these accident types differ from or are similar to those experienced by the rest of the population. This entailed developing a method for identifying accidents in which pedestrians were involved; eliminating those cases which did not involve elderly and handicapped people; investigating the remaining cases to try to establish what type of accident occurred and what were the causes; comparing the results with those from previous accident studies of the general population; and, finally, developing some testable hypotheses for countermeasures that may reduce accidents.

Methods Used

The eight month study, limited to the Atlanta Metropolitan area, was carried out in four phases:

- Phase 1. Identification of pedestrian accidents involving the elderly and handicapped.

  The initial source for pedestrian accident reports was the 1973 file of vehicular traffic accidents in the Traffic Division of the Atlanta Police Department. This file was used because it was the largest available source of serious pedestrian accidents in the City. The 1973 vehicular accident file contained reports of approximately 20,000 traffic accidents in the City of Atlanta.

  An inspection of the vehicular accident file was made in August, 1974. Each of the police reports was inspected for any type of pedestrian involvement. A thorough survey of the file revealed that pedestrians were involved in only 538 of the 20,000 accidents. The elimination of 17 reports of pedestrian accident victims living outside the metropolitan Atlanta area reduced the number of applicable accident reports to 521. Possible telephone numbers were found for only 296 of the 521 pedestrian accident victims.

A second source of pedestrian accident reports was the file of hospital records from the Surgical Emergency Clinic of Grady Memorial Hospital. A total of 153 pedestrian accident reports were selected from the 32,000 hospital records. A second hospital, Piedmont Hospital, added a further 540 cases.

- Phase 2. Interviews conducted to try to establish the facts relating to the accidents.

A total of 989 possible pedestrian accident reports were submitted to the interviewers. All of the interviews were made by telephone between December, 1974 and August, 1975. Complete interviews were received for only 105 handicapped accident victims of the 989 possible pedestrian accident victims.

- Phase 3. Conducting Field Evaluations of the Accident Sites

Engineering field studies were made for some of the accident sites identified in the interviews of handicapped pedestrian accident victims. The purpose of these field studies was to identify and describe the likely cause of each pedestrian accident. Emphasis was placed on the measurement of the physical features in the pedestrian environment at each accident site.

- Phase 4. Evaluating the Data and Drawing Conclusions

An evaluation was made of all accident reports which contained interviews with handicapped victims. The evaluation included field study cases and nonfield study cases. The researchers completed each evaluation with the full knowledge of all available information. Photographic slides, field reports, interview reports and police reports were considered in the evaluation process.

On the basis of this evaluation the researchers identified and recorded the likely causes and suggested countermeasures of each accident. Next, the likely causes were summarized and categorized into general causes. General countermeasures, based on the specific countermeasures and the general causes, were also identified and noted. A discussion of these results follows.

Results

The general causes of pedestrian accidents of elderly and handicapped people identified in this research and the number of accidents are:

1. The failure to accommodate handicapped people in the design and operation of pedestrian facilities: 15 accidents.

2. The failure to consider pedestrians in the design of vehicular traffic facilities: 17 accidents.

3. The lack of an adequate separation or delineation between pedestrian areas and non-pedestrian areas: 5 accidents.

4. The failure to insure that each street is used for its intended purpose: 2 accidents.

5. The failure of the pedestrian to consider conflicting vehicular traffic prior to crossing the street: 16 accidents.

6. The failure of the pedestrian to consider conflicting vehicular traffic while crossing the street: 9 accidents.

7. The failure of the pedestrian to use the available street crossing facilities: 15 accidents.

8. The failure of the elderly to realize and adapt to their decreased mobility: 9 accidents.

9. The driver's disobedience of vehicular traffic regulations: 14 accidents.

10. The failure of the parents or guardians to properly supervise and educate their children: 24 accidents.

11. The failure to keep the pedestrian environment clean and free of debris: 2 accidents.

12. The presence of factors which decrease visibility between the driver and the pedestrian: 6 accidents.

13. The victim's overconsumption of alcoholic beverages: 1 accident.

General Countermeasures

The general countermeasures for reducing pedestrian accidents of elderly and handicapped people identified in this research, and the number of accidents they relate to are:

1. Design and operate pedestrian facilities to accommodate the handicapped: 5 accidents.

2. Design vehicular traffic facilities for the safety of vehicular traffic and pedestrian traffic: 17 accidents.

3. Provide an appropriate delineation or separation between pedestrian areas and non-pedestrian areas: 5 accidents.

4. Use traffic engineering countermeasures to insure that each street is used for its intended purpose: 2 accidents.

5. Provide a safe school trip for young pedestrians: 3 accidents.

6. Encourage parents to take more responsibility for the supervision and education of their children: 24 accidents.

7. Provide information to school children and safety personnel about safe and proper pedestrian behavior: 17 accidents.

8. Provide information to elderly people about safe and proper pedestrian behavior: 11 accidents.

9. Prosecute dangerous drivers for the violation of traffic regulations: 14 accidents.

10. Keep the pedestrian environment clean and free from debris: 2 accidents.

11. Remove objects which obstruct visibility between drivers and pedestrians: 3 accidents.

12. Provide information to the public about the dangers associated with the overconsumption of alcoholic beverages: 1 accident.

The Five City Accident Investigation

As discussed earlier, an investigation was conducted in 5 cities to generate a typology of mobility barriers and problems. The format of the investigation made it possible to include questions on accidents (the nature of the investigation and the techniques used were set out earlier under the section on Environmental Barriers and Problems). And the results can be summarized as follows:

Conclusions

From the accident survey it can be concluded that four of the handicapped groups can be classified as experiencing higher risks in terms of accident probability.

- Developmentally restricted (mostly children)
- Wheelchair users
- Those with lower extremity impairments who walk using special aids
- Severely visually impaired

Three types of accidents predominated:

- Falls on the level (47% of all accidents). 64% of all wheelchair accidents occurred on the level.
- Falls at level changes (32% of all accidents). 44% of all accidents involving the visually impaired occurred at level changes.

- Accidents involving motor vehicles (20% of all accidents). 40% of accidents to the developmentally disabled, and 50% of accidents to those who walk with difficulty but without the use of special aids, and to those who are confused and disoriented, involved motor vehicles.

Four components of the pedestrian environment were the loci for 92% of all the accidents. In this context, an element is the smallest part of a pedestrian system—a curb ramp, a traffic signal, etc. An environmental component such as a street intersection or a park is composed from its constituent elements.

- walkways (39%)
- street intersections (29%)
- public spaces, parks (10%)
- building entrances, lobbies (14%)

And four elements of the pedestrian environment accounted for 82% of all the accidents reported.

- Walks and corridors (36%)
  - 40% of all reported accidents to the developmentally disabled
  - 56% of all reported accidents to wheelchair users
  - 40% of all reported accidents to people who use walking aids
  - 22% of all reported accidents to visually impaired people
- Street crosswalks (17%)
- Curbs, curb ramps (11%)
  - 18% of all reported accidents by wheelchair users
  - 14% of all reported accidents by people who use walking aids
  - 19% of all reported accidents by visually impaired people
- Stairs (17%)
  - 20% of all reported accidents by people who use walking aids
  - 31% of all reported accidents by visually impaired people

studies of short ramps, tactile surfaces and wheelchair dimensions

Volume 2, Hazards, Barriers, Problems, And The Law", in this series described the identification of approximately 750 problems that restrict or prevent elderly and handicapped pedestrians from moving safely around the urban environment. This large list of problems was later reduced to 18 categories. And countermeasures were developed for some of these problem categories-- those that were rated by a panel of elderly and handicapped mobility experts as being those for which solutions were most urgently needed.

Some of the countermeasures included well known devices such as curb ramps and curb cuts; devices that are part and parcel of most accessibility programs. However, from a survey of the literature, and from the field survey reports, it became clear that some curb ramps are actually hazardous. Others are not even useable by the very group that they are intended to assist. And the reason for this is that no criteria based on research had been developed that set out the design principles. The laboratory studies that are described in the report that follows were designed to establish objective criteria.

A further series of countermeasures was directed at positive cueing. Blind people use environmental landmarks as locational cues, but these landmarks are not designed for this purpose. Positive cueing as an idea was developed during the research project to extend the value of landmarks by using them to provide locational information intentionally. For example, by intentionally locating a planter for cueing, we can define the edge of a crosswalk. Or by changing the surface material of a walkway, we can indicate the boundaries of the walkway in a way that is not possible using road marking paint.

Finally, a study of static wheelchair dimensions was carried out. Wheelchairs come in several shapes and many sizes. Obviously, for the environment to be accessible, it must be designed to accommodate a reasonable range of wheelchairs. Unfortunately, the 'design vehicle' wheelchair that is to be found in most professional reference books, and even in codes and standards, is based on an 'average' wheelchair. The study reports on the results of a survey of almost all of the manufacturers of both powered and manual wheelchairs; and based on the information provided by the manufacturers, proposes static dimensional criteria.

These laboratory studies and later the field evaluation of design countermeasures are described in detail in Volume 3 of the series, "The Development and Evaluation of Countermeasures".

Curb Ramp Design Criteria

The study was directed at producing answers to the following questions:

- how steep should curb ramps be so that they can be used by most handicapped people without too much difficulty? As space for curb ramps is usually restricted what is sought is the reasonable maximum gradient. Of course, if

there are no space (nor money) constraints, then, in terms of gradient, a more gentle slope will usually be preferred to a steeper slope.

- should the gradient of curb ramps be reduced for longer ramps to make them easier to use? On the other hand, a short steep ramp may be the simplest solution for some locations. Are steeper ramps useable if they are short?

- how steep should the flares at the side of curb ramps be? The steeper the flare, the more hazardous and difficult they become for people to travel over. On the other hand, the gentler the slope, the more space they occupy and the more difficult it becomes to find sufficient space within which to locate the curb ramp.

- how much room at the top and bottom of curb ramps is necessary to permit wheelchair users to maneuver, take a run at the ramp, and stop in safety? The momentum of a wheelchair traveling down a ramp will carry it some distance beyond the bottom of the ramp. Even at the top of the ramp, the wheelchair will need space to slow down and stop.

- is it a fact that blind people cannot detect ramps easily, or do they only have difficulty with some ramp gradients?

- is it a fact that a small step or lip at the bottom of curb ramps will make it easier for the blind to detect curb ramps? Do these steps adversely affect the use of the ramp by people in wheelchairs, and others?

Methodology

1. The test site. To avoid the potential hazards and logistic problems inherent in using curb ramps in traffic in urban settings, an outdoor laboratory was constructed as a test site at Georgia Institute of Technology. The test site was designed to simulate closely, typical environmental conditions. Included in the test area were 12 curb ramps varying in gradient from 1:5.3 to 1:20. The ramps varied in length from 2 feet (.61 m) to 10 feet (3.05 m), and traversed curbs of 3" (7.62 cm), 6" (15.24 cm), and 9" (22.85 cm), dimensions that are typical for curbs in cities. The test site was designed to carry out both the curb ramp evaluations, and the texture evaluations described later.

2. The test subjects. Volunteers for testing were solicited through newspaper advertisements, television and radio spot messages, television and radio public service announcements, presentations to community groups, and through direct contact with agencies and associations that work with the elderly and handicapped. The sample tested included subjects with a variety of physical impairments; elderly people; and a group of able bodied subjects for control.

   All of the subjects were experienced travellers. The subjects with physical impairments provided a range of disabilities representative of the kind of disabilities typical of handicapped pedestrians.

Results

A. Ramp Gradient. From the tests it was clear that some of the ramps were unacceptable to several handicapped groups. Secondly, if was found that steeper ramps are acceptable if they are short. And thirdly, ramps with a one inch lip at the bottom were found to be unacceptable, and ramps with a ½ inch (1.3 cm) lip were found to be only marginally acceptable. Table 2 shows the ramp gradient recommendations.

Table 2. Ramp Gradient Recommendations

Curb Heights Not Exceeding	Maximum Gradient *				
	Gradients Steeper Than 1:8	1:8	1:10	1:12	1:16
3" (7.6 cm)	X	0	0	0	0
6" (15.2 cm)	X	X	0	0	0
9" (22.9 cm)	X	X	X	0	0

X Not Recommended
0 Acceptable

*Whenever possible slopes less than the maximum should be employed

B. Ramp detection by the visually handicapped. The purpose of this component of the study was to examine the accuracy of the statement reported earlier, 'that the blind person may fail to detect curb ramps, and may inadvertently stray into the street; and that a small step or lip at the bottom of ramps will obviate this danger'.

In this test six ramps were used: two had lips at the bottom, four had no lips and one of the ramps was a mountable curb.

For the first test, the blind subjects were asked to imagine that they were crossing a street. They were told that the pavement in front of them might continue as a level surface, or they might encounter a curb ramp or a curb. They were then asked to walk forward and to stop immediately if they detected a curb or a ramp. If they detected a ramp they were then asked to indicate the exact bottom and then the top of the ramp.

For the second test, they were asked to imagine that they were on a sidewalk approaching a street crossing that they wished to use. They were told that before the street crossing they might encounter a wheelchair ramp, or the sidewalk might continue on the level. Again, they were asked to walk forward and to stop immediately if they detected a ramp; if they did, then they were asked to indicate the exact top and then the bottom of the ramp.

Conclusions

The [illegible] the blind subjects had little difficulty in detecting [illegible] ely determining the top and the bottom of the ramps. The [illegible] oratory results, and these results [illegible] e in typical curb ramps [illegible] s. However, it does indicate that the [illegible] and fear of inadvertently s[illegible] to the street on a curb ramp may [illegible] a substantial risk [illegible] wh[illegible] are exercising normal [illegible] ation. [illegible] results do [illegible] ter ramps, 1:16 and 1:20, are somewhat more difficult to [illegible]

Providing [illegible] ip on the [illegible] the bottom was shown to have more disadvantages than advantages, but the lip becomes a trip hazard, and does not substantially impr[illegible] detectability.

Recommendations

[illegible] should be located in the direct path [illegible]

[illegible] ramp and the street or walkway is [illegible] differential is 1:20 for cross slope), there [illegible] that is detectable by the blind [illegible] walkway ramps in this way.

[illegible] ys should not be [illegible]

[illegible] ts to crossing [illegible] a [illegible] ne. A slight be [illegible] ter people [illegible] e most adversely affected. Both of [illegible] gr [illegible] ver [illegible] ned about the [illegible] [illegible] co [illegible] bout the typically high [illegible] [illegible] owe [illegible] e needed to cross t[illegible] [illegible] [illegible] [

b. Ramp flares that lie within the paths that pedestrians must use, should not be steeper than 1:12 in the direction at right angles to the slope of the curb ramp.

c. Ramp flares that do not lie within the path that pedestrians must use should not be steeper than 1:10 in the direction at right angles to the slope of the curb ramp.

d. In general, flares steeper than 1:12 should be avoided.

D. Stopping distances--manual wheelchairs. To establish wheelchair stopping distances, the subjects were asked to stop as soon as possible after negotiating the ramps. Then the distance from the tip of the toe of the wheelchair user to the top (or bottom) of the ramp was measured.

Conclusions

A very small number of subjects were able to stop immediately after traversing a ramp. The mean distance travelled before stopping, after ascending the ramps, was 54.4" (138.2 cm); and 52.9" (134.4 cm) after descending the ramps. (Of course, the length of the chair is included in these figures, and from the discussion on wheelchair dimensions which follows, the mean length of wheelchairs was found to be 44.7" or 113.5 cm.)

Recommendations

To allow sufficient space at the top or bottom of ramps for most wheelchair users, a distance of 66" from the top or bottom of the ramp should be provided. Sixty-six inches will be adequate for 85% of descending wheelchairs, and 91% of ascending wheelchairs.

Tactile Surface Materials for Visually Impaired Pedestrians

Regardless of their travel abilities there are some environmental conditions that tax the skills of visually impaired pedestrians to the limit. These are situations where there is too little pertinent information to be sensed, or where the information is confusing, or where they are unfamiliar with the terrain and there are unforseen hazards.

There are well tested ways of dealing with all these conditions adequately, if not always conveniently, and these techniques are included in the vocabulary of blind mobility training programs. However, these problems are still perceived by many visually impaired people as being the object of apprehension or, at least uncertainty. And this has led to the suggestion that the cognitive mapping process that is one of the techniques used by most visually impaired people can be reinforced by the provision of active environmental cues in addition to the passive cues that are routinely used. One type of active environmental cue that has been suggested is the use of detectable, special walkway surfaces to inform or alert visually impaired

pedestrians. These surfaces would be selected for their ease of detection, and located where they would provide visually impaired people with information such as the presence of a hazard such as some steps in the immediate vicinity; or as a directional pathway across an oblique angled crosswalk, for example, or even as a guideway strip through transit terminals, college campuses, etc.

It is implicit in the proposal that the nature, extent and location of the tactile walkway materials must be known to the blind group for whom it is intended, and the material must be reasonably easy to detect. The device is not useful or useable by all visually impaired people. It is most likely to be useful to those who use long canes, and those with partial vision, and the specific applications would have to be learned in the same way that other 'landmarks' have to be remembered.

The purpose of this portion of the study was to evaluate several materials to determine which were not easily detectable by the visually handicapped. Of special interest were materials which can be applied to existing sidewalks and walkways.

Methodology

The test site was the same as that used for the curb ramp evaluations. It included eleven textured surfaces and a blank, or dummy section, consisting of a section of normal sidewalk and used as a control. The textured surfaces were all of a type that could be used (in conjunction with) concrete sidewalks.

After examining the textured surfaces, each subject was given the opportunity to detect the surfaces one at a time in random order. If the textured surface was detected, the subject rated the ease of detectability on a four-point Likert scale.

In separate tests, the textured surfaces were also evaluated for their effects on the comfort, stability and balance of the handicapped subjects used in the ramp study discussed earlier. Subjects traveled over each textured surface and rated it using a four-point Likert scale.

Findings

1. Using the normal mobility techniques applicable to the outdoor environment (and this differs from that normally used indoors), most blind subjects were able to detect certain types of the walkway surface material changes with little difficulty.

2. Further work is necessary to determine standard specifications for detectable walkway surfaces, and to explore the range and types of materials that are practical for outdoor construction.

3. For the materials tested, a strip that is 30" to 48" long is needed for detection.

   Table 3 indicates those materials which can be readily detected when they occur within a broom finish concrete walkway, and those that are not readily detectable.

Recommendations

1. In those locations where a detectable walkway surface can be used to provide warnings or general navigational information, at least a 48" length of the walkway should be treated.

2. Either a resilient material should be considered or strips of thermoplastic 6" wide and set 6" apart across the walkway. If an exposed aggregate such as pea gravel is to be formed in the walkway, this should not be made so rough that it will affect adversely the passage of people in wheelchairs and other handicapped pedestrians.

Table 3. Detectable Tactile Walkway Signals for Exterior Use

WALKWAY MATERIAL	SIGNAL MATERIAL	DETECTION
Broom Finish Concrete	Asphalt*	N
" " "	Ruled Concrete (grooves 4" or 10.16 cm spacing)	N
" " "	Exposed Aggregate (pea gravel)	
" " "	Concrete Burlap Finish**	N
" " "	Concrete Washboard***	Y
" " "	Brick Paving	N
" " "	Thermoplastic Strips (6" or 15.24 cm)	
" " "	Pliant Polymer	
" " "	Plastic Tennis Court Cushion Coating	
" " "	Thermoplastic Sheet	
Asphalt	Broom Finish Concrete	

* Regular Mix

** Burlap laid into wet concrete and pulled before initial set is complete

*** Wet concrete struck with the edge of a board to give a washboard effect with grooves not more than 1/8" (3.17 cm), or so, apart

N Surface difference not detectable by cane

Y Surface difference detectable by cane

Wheelchair Dimension

Recommendations for a wheelchair design [illegible] static data. The specification for wheelchair [illegible] only the measurements of the vehicle [illegible] between the planes of the [illegible] wheelchair [illegible] of people in [illegible] with disabilities that [illegible] wheelchair [illegible]

The study of wheelchairs that was carried out did not deal with these dynamic tolerances, only the static dimensions of the vehicle, and therefore the recommendations should be considered in this context.

Methodology

To update available information on wheelchairs, both powered and unpowered, a survey of manufacturers in the United States was undertaken.

The following information was sought for each model:

- overall length
- overall width
- overall height
- wheel diameters, front and rear
- turning radius
- front and rear overhangs
- ground clearance
- weight
- wheel type
- propulsion system

Data on a total of 201 models was received from seven manufacturers.

Findings

From the frequency distributions, it can be concluded that:

- Length:
  - 83% of all the models are less than 47" (119.38 cm) long.
  - 55% of all the models are less than 46" (116.84 cm) long.
  - 33% of all the models are less than 45" (114.3 cm) long.

The conventional wheelchair offers a wide range of leg and footrest adjustment. The front rigging is usually designed for two positions, for footrest and for legrest. In the footrest position the legs are bent at the knee in the usual sitting stance. In the legrest position, the leg is supported in a position approximately parallel to the ground. For the footrest and legrest position there is the opportunity for additional adjustments. This clearance can be reduced to almost nil, or increased to suit the needs of the user. The length dimension is an overall length based on the maximum extension in the footrest position. For an 'average' extension (from information provided by the manufacturers), this overall length will be reduced by about $1\frac{1}{2}$ inches (3.81 cm). (For a footrest rigging, the overall length will be increased by about $1\frac{1}{2}$ inches or 3.81 cm).

- Width:
  - 39% of all the models are less than 28" (71.12 cm) wide.

- 76% of all the models are less than 27" (68.58 cm) wide.
- 66% of all the models are less than 26" (66.04 cm) wide.

- Weight:

  - 76% of all the models are less than 51 lbs. (23 kilos) in weight.
  - 62% of all the models are less than 46 lbs. (21 kilos) in weight.
  - 49% of all the models are less than 44 lbs. (19 kilos) in weight.

Conclusions and recommendations

There are a very large number of wheelchair models manufactured; however, from the frequency distributions it appears that most of the available models have dimensions that are clustered into quite a small number of sizes. As it was not possible to obtain sales information on the various models, all we can do is to hypothesize that the bulk of the sales (and perhaps the models in use) are clustered in a similar manner.

The static dimensions of wheelchairs are an important influence on environmental design decisions. If the dimensions used as criteria are too small, then some wheelchairs will be unable to use the environment. If the recommended dimensions are too great, then the costs of providing for wheelchairs may be unnecessarily high. The selection of a design vehicle dimension that is only one inch greater than an alternative choice may make a substantial difference. For example, 55% of all models are less than 46" (116.84 cm) in length, but 83% are less than 47" (119.38 cm) in length. So the additional inch may affect 28% of the users.

To recommend a length of less than 46" (116.84 cm) would omit a large number of units, and to recommend more than 46" (116.84 cm) would not increase the number of units, substantially. This suggests that an overall length of 46" should be used. This length, as discussed earlier, is based on the maximum extension in the footrest position. And it could be argued that an average extension might be more appropriate for design purposes--this would reduce the overall length by $1\frac{1}{2}$" (3.81 cm). However, the chair users' footwear normally projects beyond the footrest, by approximately $1\frac{1}{2}$" or 3.81 cm, and should therefore be included. For these reasons, an overall design length of 46" is recommended.

The frequency distribution of wheelchair widths, also has a pronounced step characteristic at 27" (68.59 cm), and 89% of all models are 27" (68.59 cm) or less. Therefore, it is recommended that an overall width of 27" (68.59 cm) should be used.

The frequency distribution of wheelchair heights, is bi-modal with a major peak at 36" (91.44 cm) and a minor peak at 50" (127 cm). Nevertheless, 75% of all models are less than 42" (106.68 cm) high, so a design height of 42" (106.68 cm) is recommended.

There may be special circumstances where it is necessary to consider a maximum anticipated wheelchair weight, but to allow for 76% of all models a design weight of 51 lbs. (23 kilos) is recommended.

Summary of recommendations: (Fig. 1)

Length	46" (116.84 cm)
Width	27" (68.59 cm)
Height	42" (106.68 cm)
Weight	51 lbs. (23 kilos)

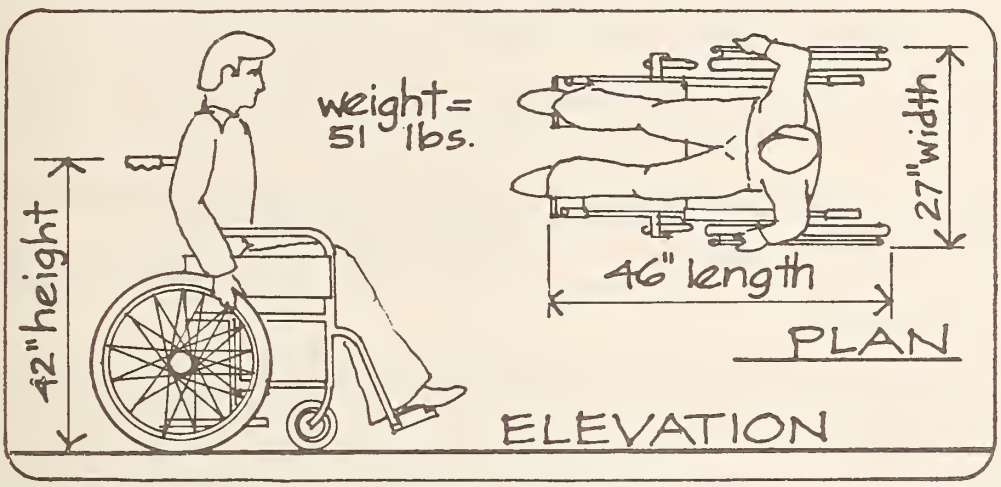

Figure 1 Recommended Static Wheelchair Dimensions

the field testing of countermeasures

Part two of Volume 3, "The Development and Evaluation of Countermeasures" deals with the field testing of ten environmental modification countermeasures. As discussed earlier, the countermeasures were developed as solutions for the most acute problems as rated by a panel of mobility experts.

Cities were selected that have substantial pedestrian activity; a range of climates; a large number of elderly and handicapped; on-going improvement programs for these groups; active consumer organizations for these groups; an interest in participating and a willingness to pay for the construction of the countermeasures. Twenty five cities volunteered and six were finally selected: Atlanta, Georgia; Athens, Georgia; Baltimore, Maryland; Boulder, Colorado; Clearwater, Florida; and Sioux City, Iowa.

Methods Used

In each of the cities, sites for installation of the countermeasures and sites to act as control locations were selected jointly by the city and the Pedestrian Research Laboratory. Detailed design suggestions for the countermeasures were then submitted to the city, and adapted to conform to the engineering and construction practices followed by the city. The cooperating cities had total responsibility for scheduling and constructing the countermeasures, including bearing the costs of engineering and construction.

Before construction started, it was necessary for 'before' data gathering and observations to be collected at each of the test and control locations. Once construction was completed, an acclimation period was set aside to permit persons using the area to become accustomed to the changed conditions. The length of this acclimation period was a minimum of 30 days.

For the 'before' and 'after' tests, criteria were developed to evaluate:

- The suitability of the countermeasure designs.
- The impact of the various countermeasures upon the normal users of the locations where they were installed.
- The degree of success with which the countermeasures solved the problems of the elderly and the handicapped for which they had been designed.
- Any other effects, both positive and negative, which the countermeasures might have generated.

The general procedures developed by The Pedestrian Research Laboratory involved on-site evaluations of two distinct types:

- Observations of use of the countermeasure locations by persons (including both pedestrians and drivers of vehicles) who normally use those locations.
- Observations of use of the same locations by specially arranged groups of handicapped persons.

Data on Use of the Test Locations By the General Population

These data involved measuring the use of the test locations by persons who normally travelled through those locations. This included measures of changes in the amount and type of use, by pedestrians and drivers; and examination of the behavior of pedestrians, with emphasis given to behavior which was unsafe, or which had the potential of leading to an accident.

The measures used to provide this information included the following:

- Vehicular traffic volumes
- Vehicular turning movement
- Pedestrian travel volumes
- Pedestrian crossing outside the marked crosswalk
- Pedestrians suddenly moving at an accelerated pace
- Pedestrians stopping within the street while crossing

- Pedestrians stepping into the street to begin crossing, and then returning to the sidewalk
- Pedestrians changing course or swerving while crossing
- Pedestrians beginning crossing against the traffic signal
- Pedestrians caught in the intersection by a signal change
- Pedestrian crossing time
- Pedestrian use of ramps and curb cuts
- Pedestrians' obviously avoiding the use of curb cuts

Three complementary data collection techniques were used for the countermeasure evaluations.

1. Direct recording of specific events as defined by the evaluation criteria. In this approach, the observer recorded, in tabular form, only those events which had been identified by the criteria. The advantage of this technique was its simplicity and ease of use, in both the collection and processing of data. This technique was most appropriate for recording data on traffic volumes and turning movements, and pedestrian travel volumes, since these were specific events requiring no interpretation by the observer.

2. Time lapse photography. The actions and behavior of persons using the countermeasures were recorded on film. A time lapse interval was chosen which balanced the need to conserve film, for economic reasons, with the need for sufficient detail to enable the recording of specific events, such as when a person's foot first leaves the curb. Investigation indicated that a film speed of 6 frames per second was the optimum for the purposes of this work. Time lapse photography provides a permanent record which can be reviewed as often as desired, and it provides a record of all events occurring during the use of a countermeasure--including unexpected but potentially significant events, as well as those which were set out in the evaluation criteria. Time lapse photography was used to record the responses of special groups of handicapped individuals.

3. Pedestrian 'tracking'. All relevant events were recorded on forms which were map representations of the intersections (or other locations) where the countermeasures were installed. With this technique, the precise paths followed by the pedestrians were recorded, as were all events which occurred as they proceeded along those paths.

   Pedestrian 'tracking' was used to record pedestrian behavior, the impact of countermeasures on pedestrian safety, and to measure the reduction in barriers to mobility and increased accessibility for the elderly and handicapped.

Evaluation of the Use of the Countermeasures by Special Groups of Handicapped Persons.

It would be unreasonable to expect a significant number of handicapped persons to pass through the countermeasure locations during the evaluation of their use by the general population. Yet, it was important to have handicapped individuals participate in the countermeasure evaluations. So it was decided to set up special tests by these groups.

Members of two subgroups of handicapped persons were considered especially important to bring to the sites to evaluate the countermeasures. These were the visually handicapped, and persons using wheelchairs. Arrangements were made therefore to bring handicapped volunteers to the test sites to evaluate the countermeasures.

The subjects were asked to use the countermeasures individually. They were given a prescribed route to follow, which took them through the test location in several different ways, from several directions. A member of the research team remained a short distance from the test subject throughout the evaluation, not so close as to influence the use of the countermeasures, but close enough to intervene if a test subject embarked on a seriously dangerous path, or was otherwise in need of assistance.

Time lapse photography was used to record the evaluations. The cameras and operators were located in an unobtrusive location above the test location, such as on the roof of a building. The 'tracking' recording techniques described earlier were also used to supplement the data from the time lapse photography.

The measures that were used in the evaluation of the countermeasures by the special handicapped groups were essentially the same measures used for the general population.

The following countermeasures were constructed and evaluated:

Countermeasure Number	Countermeasure Description
1	Widened Sidewalk at Intersection
2	Pedestrian Island
3	Midblock Crossing
4	Widened Crosswalk
5	Textured Furniture Strip
8	Single Conventional Curb Ramp
9	Double Conventional Curb Ramp
11	Ramped Full Quadrant
12	Single Add-On Ramp
15	Right Turn on Red Prohibition

These countermeasures were not evaluated, because of cost, inability to find a city willing to install them, or other difficulties.

Countermeasure Number	Countermeasure Description
6	Raised Intersection Box
7	Ramped Sidewalk
10	Ramped Quadrant
13	Double Add-On Ramp
14	Paint Indications--Inlets and Covers

Problem Categories

A. Safer and easier ways to cross streets. The specific problems for which solutions were sought are:

i) VERY WIDE STREETS ARE DIFFICULT OR IMPOSSIBLE TO CROSS FOR THOSE WITHOUT MUCH STAMINA AND AGILITY, AND PEDESTRIANS ARE EXPOSED TO MOVING AND TURNING TRAFFIC FOR A SUBSTANTIAL PERIOD OF TIME.

For the problem, the following countermeasures were developed for evaluation:

- Countermeasure No. 1, The Widened Sidewalk. In this solution, the road width is reduced at pedestrian crossings by widening the sidewalks out to the edge of the parking lane, as shown in Figure 2.

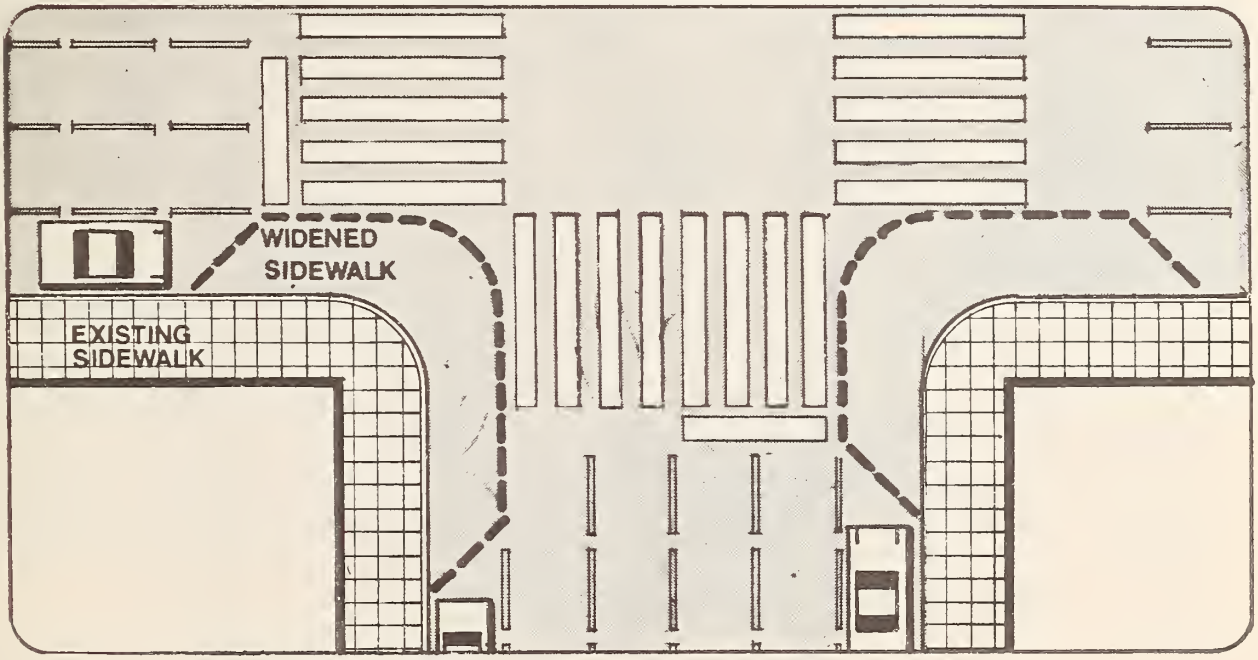

Figure 2 Widened Sidewalk

For locations where the street crossings are eighty feet (24.4 m) or more, and where a parking lane(s) exists, the road width is reduced at pedestrian crossings by widening the sidewalk(s) out to the edge of the parking lane as shown in Figure 2.

From the evaluation, the countermeasure is successful for the following reasons:

- Vehicular flow was not affected.
- There was a significant reduction in pedestrian crossing time.
- Vehicle driver's view of pedestrians waiting to cross, and the pedestrians' view of vehicles was improved.
- Increased space for benches, curb ramps and street furniture away from the sidewalk was made available.
- Countermeasure No. 2, The Pedestrian Refuge Island. In this solution, the effective width of the street is reduced by introducing a pedestrian island which can be used to divide the crossing trip into two, as shown in Figure 3.

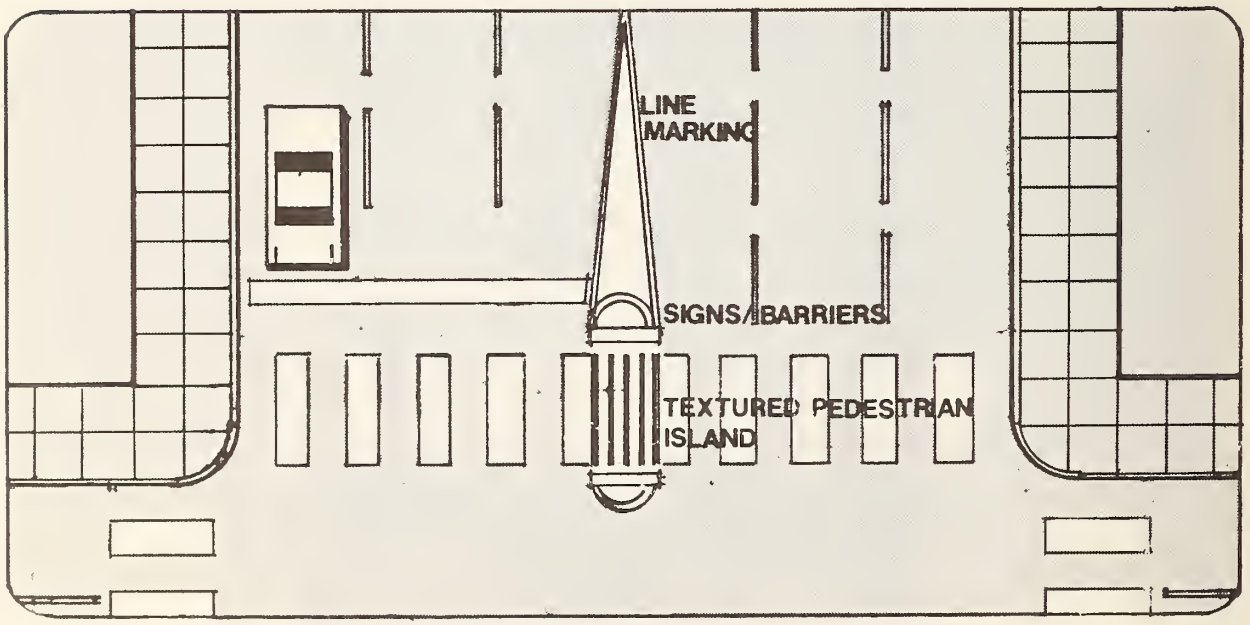

Figure 3 Pedestrian Refuge Island

For crosswalk locations where there is a considerable amount of pedestrian traffic (or elderly and handicapped pedestrian traffic), and where it would be difficult or dangerous to cross the entire roadway at one time in safety. This may occur at signalized intersections to provide a refuge between traffic streams; on a multi-lane roadway; at large or irregularly shaped intersections. The effective width of the street is reduced by introducing a pedestrian island which can be used to divide the crossing trip into two parts--as shown in Figure 3. Caution should be exercised when introducing a pedestrian island that could be struck by an oncoming vehicle. The island should be clearly signed and made as visible as possible to passing motorists.

From the evaluation, the countermeasure is successful for the following reasons:

- About 18% of all pedestrians used the island to avoid conflicts with vehicles.

- In one half of all crossings, people in wheelchairs paused, or stopped, on the island, using it as a refuge.

However, for visually impaired people, two changes to the design are necessary:

- The floor surface of the island must be detectable and different from that of the crosswalk, either by an appropriate change of texture or by raising the surface of the island by means of a curb cut or curb ramps.

- Where the refuge island forms a physical barrier to crossing the street at any point, then the crosswalk marking should be detectable to the visually impaired, in order to direct them through the island opening.

ii) THE DRIVERS OF VEHICLES OFTEN IGNORE MIDBLOCK CROSSWALKS AND PEDESTRIAN RIGHTS, EVEN IF THE CROSSWALK IS WELL MARKED.

Besides the problems occasioned by very wide streets, there are also problems associated with midblock crossings. The drivers of vehicles often ignore midblock crosswalks and pedestrian rights, even if the crosswalk is well marked.

For this problem, the following countermeasure was developed for evaluation:

- Countermeasure No. 3: Midblock Crossing, with painted markings that are intended to be more obvious to drivers of vehicles and therefore to encourage drivers to reduce speed and respond to pedestrians, as shown in Figure 4.

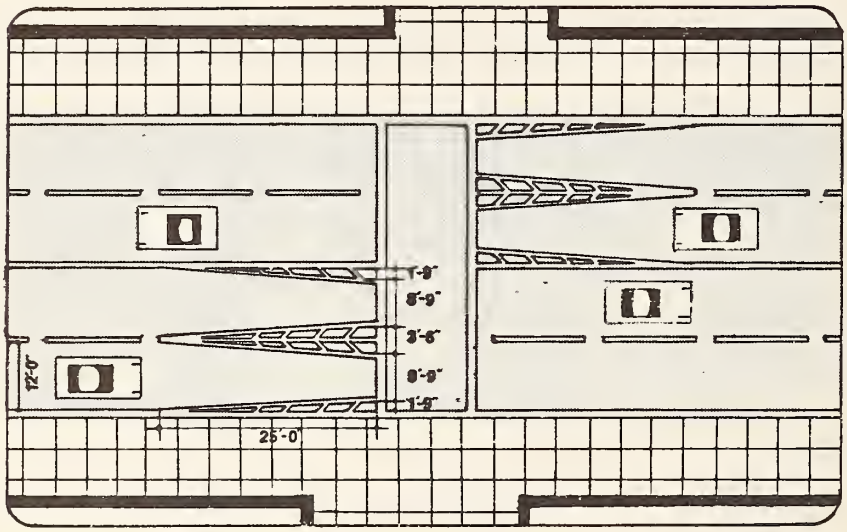

Figure 4 Midblock Crossing

From the evaluations, the results were inconclusive. There is some evidence that vehicle drivers responded better to this type of marking than to the conventional markings; and there is good evidence that pedestrians are less likely to cross away from the crosswalk. A further evaluation of this countermeasure would be useful.

iii) NARROW CROSSWALKS TEND TO BE CONGESTED AND INCREASE THE RISKS OF PEOPLE BEING JOSTLED AND LOSING THEIR BALANCE. AND THERE IS AN INCREASED RISK OF VEHICLES STOPPING WITHIN AND BLOCKING THE CROSSWALK.

For this problem, the following countermeasure was developed for evaluation:

- Countermeasure No. 4: Widened Crosswalks. In this solution, the crosswalks at intersections are increased in width.

This countermeasure was intended as a device to reduce the effects of pedestrian congestion where people with poor balance risk being jostled or bumped. Secondly, it is intended as a device to reduce the extent of vehicles stopping within the crosswalk.

From the evaluations, it is concluded that for the level of pedestrian and vehicular activity present at the test sites, the countermeasures were ineffective.

iv) WHERE RIGHT TURNS-ON-RED ARE PERMITTED, AND THE DRIVER'S VIEW TO THE LEFT IS OBSCURED BY A PLANTING OR BUILDINGS, ETC., THEY TEND TO MOVE THEIR VEHICLES INTO THE CROSSWALK TO IMPROVE THEIR SIGHT LINES. THIS CAUSES INCREASED INCONVENIENCE AND HAZARD TO PEDESTRIANS.

For this problem, the following countermeasure was developed for evaluation:

- Countermeasure No. 15: Right-Turn-On-Red-Prohibition. In this solution, where the view to the left is obscured, right-turn-on red movements would be prohibited.

From the evaluations, this countermeasure is effective in that vehicular obstruction of the crosswalk was significantly reduced without reducing traffic volumes.

v) AT INTERSECTION CROSSWALKS, PARKED VEHICLES, STREET FURNITURE AND PLANTINGS OFTEN OBSCURE PEDESTRIANS, AND PARTICULARLY THOSE IN WHEELCHAIRS AND THOSE OF SMALL STATURE.

For this problem, the following countermeasure was developed for evaluation:

- Countermeasure No. 1: The Widened Sidewalk. This countermeasure, which has already been described, puts the pedestrians who are preparing to cross, in a position where they will not be obscured by parked vehicles, etc.

B. Problems at curbs and curb ramps. The specific problems for which solutions were sought are:

i) CURBS ARE A BARRIER FOR MANY ELDERLY AND HANDICAPPED PEDESTRIANS. CURB RAMPS ARE NEEDED, BUT THERE IS NO SINGLE DESIGN THAT IS UNIVERSALLY APPLICABLE. WHICH OF THE FREQUENTLY USED DESIGNS WORK WELL (IN THE APPROPRIATE ENVIRONMENT)?

ii) CURB RAMPS MAY BE HAZARDOUS TO SEVERELY VISUALLY IMPAIRED PEDESTRIANS IN THAT THEY MAY NOT NOTICE THEM AND WANDER OFF INTO THE STREET. WHICH OF THE FREQUENTLY USED DESIGNS (AND LOCATIONS) ARE THE SAFEST AND MOST DETECTABLE?

iii) SOME CURB RAMPS MUST BE LOCATED IN SIDEWALKS SUCH THAT PEOPLE IN WHEELCHAIRS MAY HAVE TO TRAVEL ACROSS THEM IN ORDER TO ROUND A CORNER, ETC. WHICH OF THESE CURB RAMP DESIGNS ARE REASONABLY ACCESSIBLE FROM THIS POINT OF VIEW?

For these problems, the following curb ramp countermeasures were developed for evaluation:

- Countermeasure No. 8: The Single Conventional (Recessed) Curb Ramp. In this solution, a single curb ramp is set into the sidewalk at the corner, facing the center of the intersection, as shown in Figure 5.

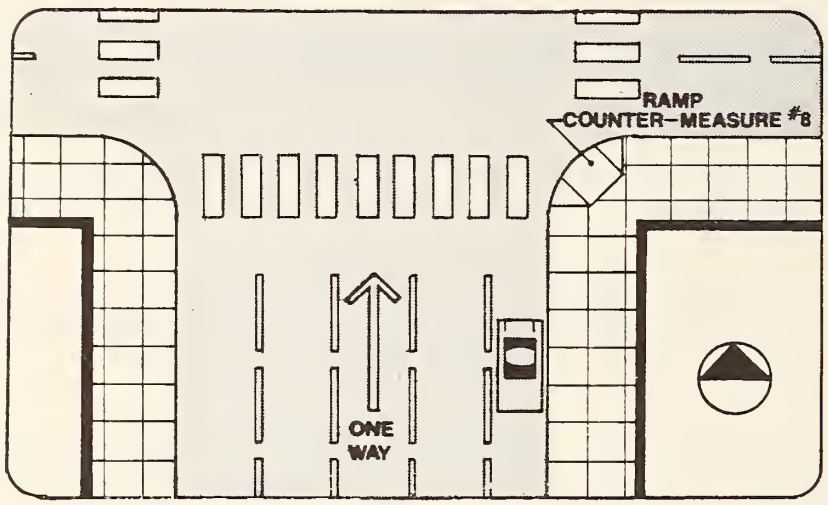

Figure 5 Single Conventional (Recessed) Curb Ramp

This type of curb ramp is widely used, not always in suitable locations. For the evaluation, a common type of location was chosen.

From the evaluation, this particular layout is considered to be potentially hazardous because wheelchair users were forced to travel into the path of moving vehicles. However, if the crosswalk markings provided a zone at least 4 feet (1.22 m) wide at the bottom of the curb ramp, the design might be effective.

- Countermeasure No. 9: The Double Conventional (Recessed) Curb Ramp. In this solution, two curb ramps are set into the sidewalk at the intersection at right angles (usually) to each other, and facing into the crosswalks, as shown in Figure 6.

This solution is also frequently used and is intended to avoid the problems associated with the single conventional curb ramp; or for locations where there is a drain at the corner.

From the evaluations, the countermeasure is successful.

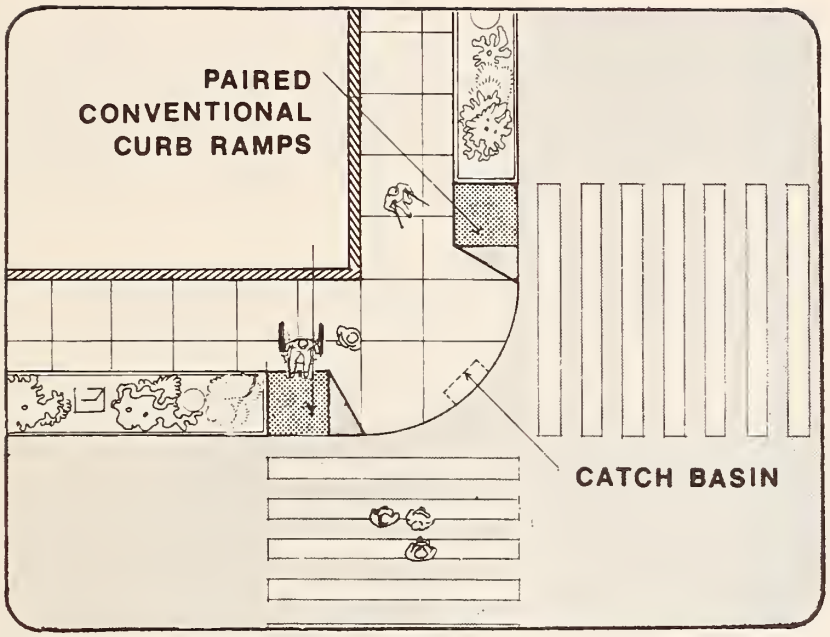

Figure 6 Double Conventional (Recessed) Curb Ramp

- Countermeasure No. 11: The Ramped Full Quadrant Curb Ramp. In this solution, the curb ramp occupies the entire sidewalk quadrant and serves both crosswalks, as shown in Figure 7.

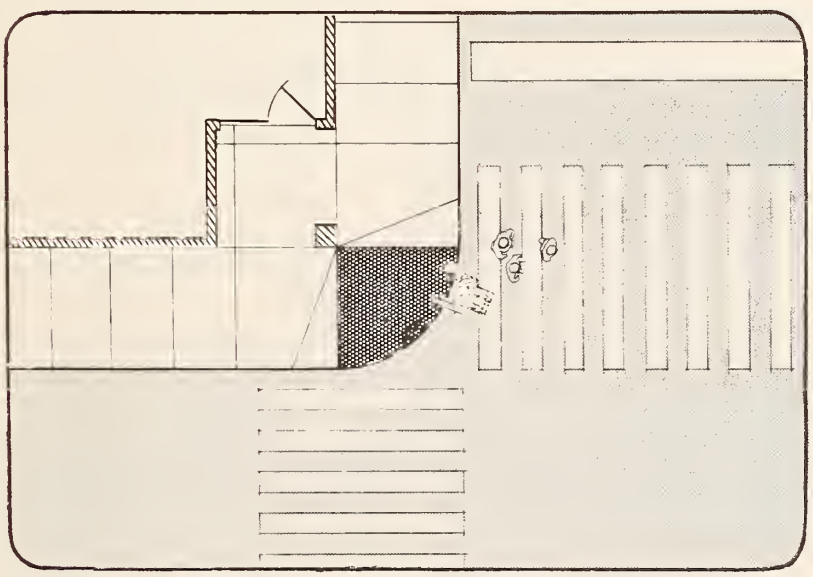

Figure 7 Ramped Full Quadrant Curb Ramp

This countermeasure is intended for narrow sidewalks.

From the evaluations, the countermeasure is reasonably effective; however, it does increase the difficulty for wheelchair users who must travel over it when rounding the corner. To minimize this difficulty, the flares of the quadrant should have the same slope as the rest of the quadrant.

- Countermeasure No. 12: The Single Add-On Curb Ramp. In this solution, the curb ramp is formed by making a ramp in the street beyond the curb, but following the curb line (see Figure 8).

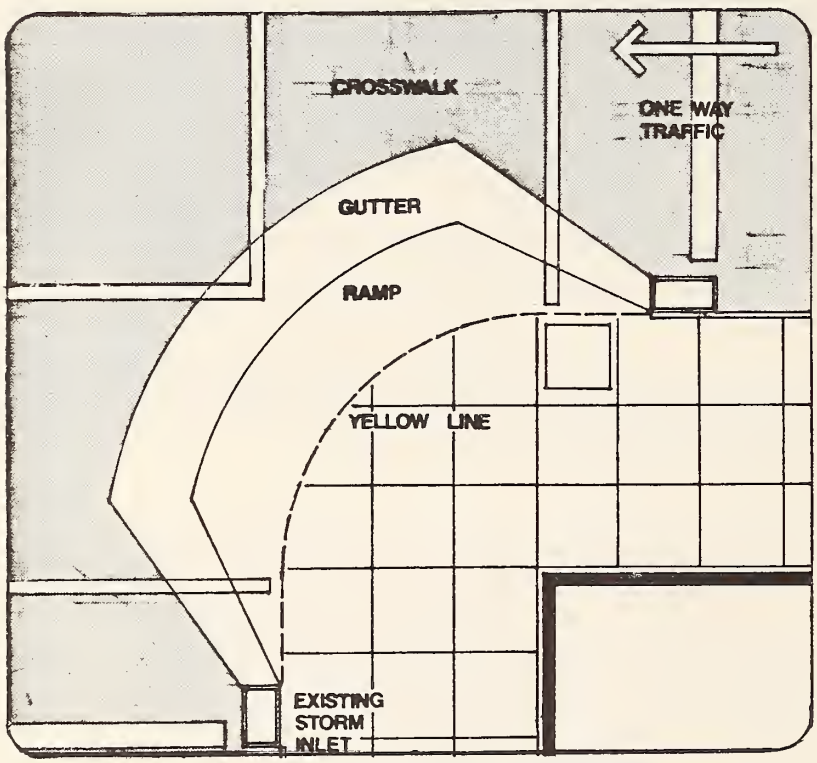

Figure 8 Single Add-on Curb Ramp

The countermeasure is intended for locations with very narrow sidewalks.

From the evaluations, it is concluded that it may be unsafe for visually impaired people to introduce this type of ramp in cities where this is not the usual design used. In cities where this design is commonly used, the design seems effective.

The following countermeasures for problems encountered at curb and curb ramps were not evaluated. However, they should be considered for future research.

- Countermeasure No. 6: The Raised Box. In this solution, the whole street intersection is raised to the level of the sidewalks, eliminating the step at the curb. The pavement for vehicles is then ramped up to the intersection, as shown in Figure 9.

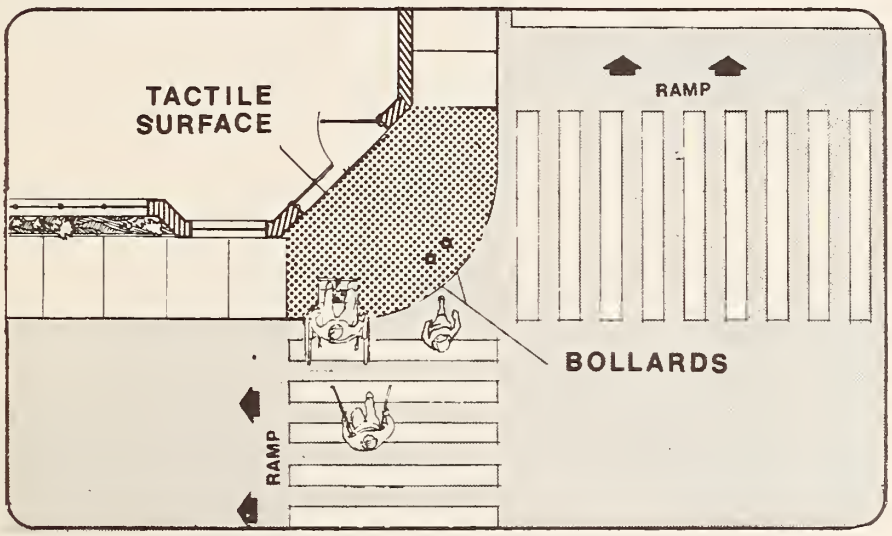

Figure 9 Raised Box

- Countermeasure No. 7: The Ramped Sidewalk. In this solution, for very narrow sidewalks, the sidewalk is ramped down to the corner quadrant, (see Figure 10).

This countermeasure is intended for locations where the sidewalks are too narrow to accept curb ramps.

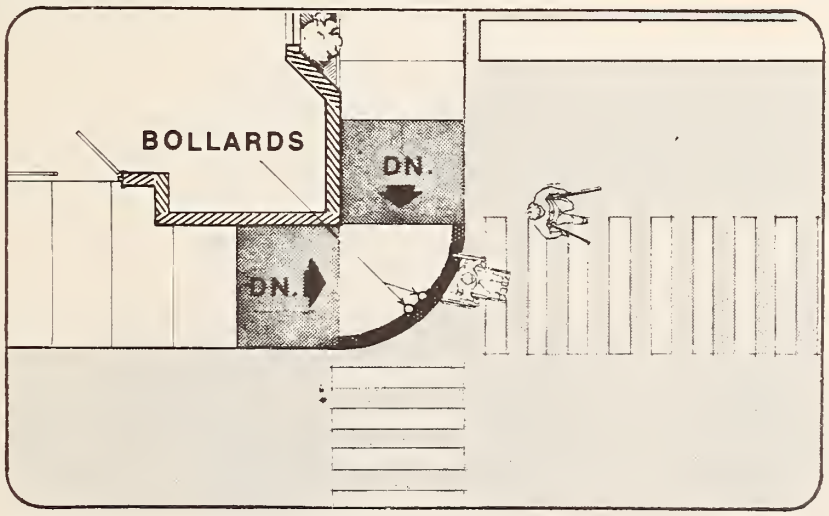

Figure 10 Ramped Sidewalk

- Countermeasure No. 10: The Ramped Quadrant Curb Ramp. In this solution, the whole outside of the sidewalk is ramped to form a continuous ramp that serves both crosswalks, as shown in Figure 11.

This countermeasure is intended for wide sidewalks, as an improved version of the conventional curb ramp; wheelchair users are not forced into a path outside the crosswalk.

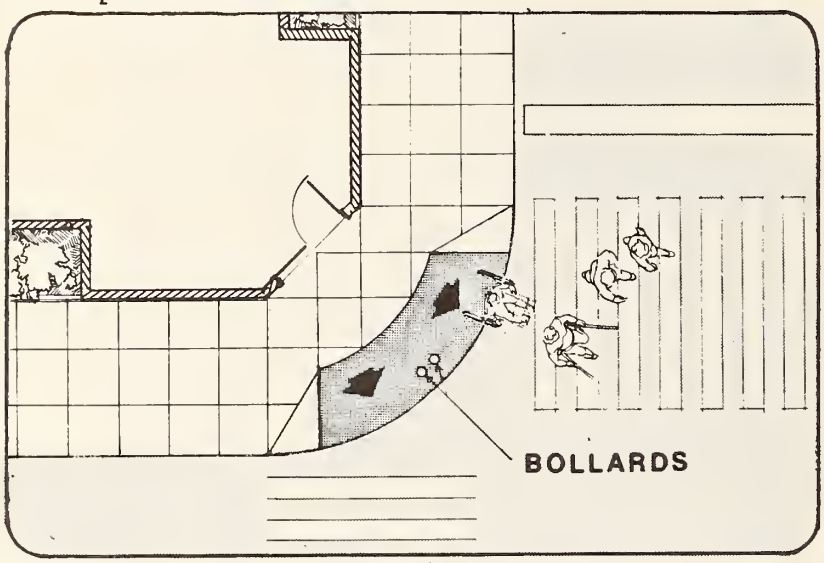

Figure 11 Ramped Quadrant Curb Ramp

- Countermeasure No. 13: The Double Add-On Curb Ramp. In this solution, two curb ramps are added, each serving one crosswalk (see Figure 12).

This countermeasure is intended for locations where the single add-on ramp cannot be easily constructed; for example, where there is a corner drain.

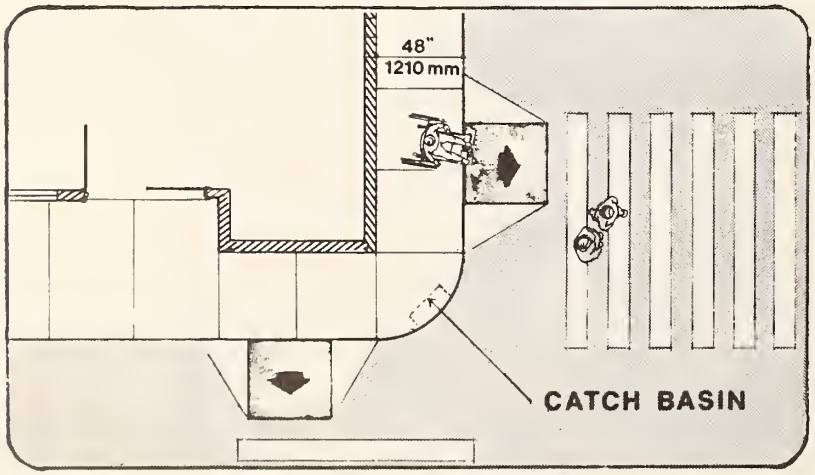

Figure 12 Double Add-On Curb Ramp

C. The location of street furniture. The specific problems for which solutions were sought are:

i) STREET FURNITURE—MAIL BOXES, TRASH CONTAINERS, POLES, PARKING METERS, MANHOLE COVERS, GRATING, ETC., ARE LOCATED ON SIDEWALKS IN A HAPHAZARD, UNPLANNED MANNER. THIS FURNITURE IS USEFUL TO VISUALLY IMPAIRED PEOPLE FOR LOCATING THEMSELVES, BUT OFTEN THE MULTIPLICITY OF OBJECTS ARE CONFUSING, AND BARRIERS TO DIRECT MOVEMENT, AND COVERS AND GRATINGS MAY CAUSE SLIPS AND TRIPS.

For this problem, the following countermeasure was developed for evaluation:

- Countermeasure No. 5: The Textured Strip. In this solution, the street furniture is separated from the main sidewalk path by means of a surface strip that is detectable by visually impaired pedestrians, as shown in Figure 13.

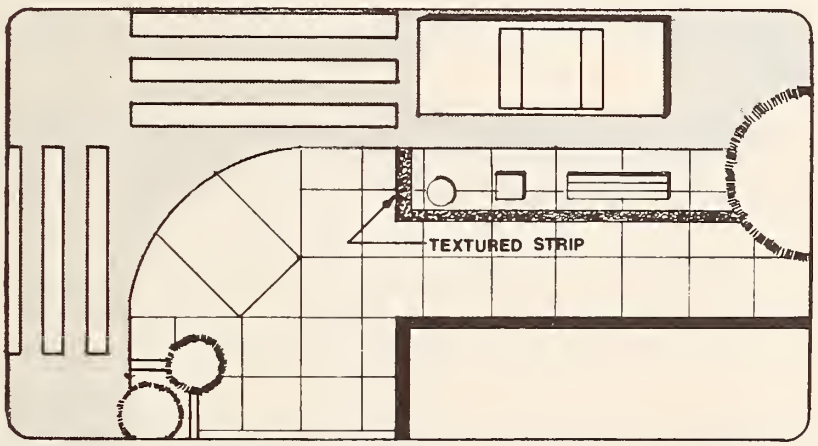

Figure 13 Textured Strip

This countermeasure is intended as a device to indicate to visually handicapped people a direct path on sidewalks that avoids street furniture and other obstructions.

From the evaluation, the countermeasure is effective.

- Countermeasure No. 14: Painted Manhole Covers and Gratings. In this solution, manholes and gratings are made more obvious by painting them a bright color that contrasts with the surrounding walkway.

The countermeasure was not evaluated.

D. Location and warning cues for the visually impaired. The specific problem from which a solultion was sought is:

i) THAT VISUALLY IMPAIRED PEOPLE MAY FAIL TO DETECT POTENTIAL HAZARDS SUCH AS A STAIR OR A RAMP.

For this problem, the following countermeasures were developed for evaluation:

- Countermeasures No. 9 and 11, described earlier, where the curb ramps and their surroundings have been treated with a detectable surface.

E. The lack of places to rest in safety and comfort. The specific problem for which a solution was sought is:

i) FEW CITIES PROVIDE SPACE ON SIDEWALKS FOR BENCHES AND WHEELCHAIRS WHERE PEOPLE WITH LIMITED STAMINA CAN REST.

For this problem, the following countermeasures were developed for evaluation:

- Countermeasure No. 1, The Widened Sidewalk, and Countermeasure No. 2, Pedestrian Island Refuge. These solutions have been described earlier, and make possible additional space for these rest areas.

Other Conclusions

During the evaluation of the countermeasures, several events were observed from which conclusions can be drawn and recommendations made.

- Lips, or small steps, at the bottom of curb ramps cause considerable difficulty to people in wheelchairs and may, in fact, be hazardous. These lips should not be constructed. This confirms similar findings from the laboratory studies.

- Crosswalks should be constructed of materials that are different from that of the curb ramps (and sidewalks, if these are flush with the crosswalk), so that severely visually impaired people may detect the surface change.

- Where planters, or other barriers to access to sidewalks from the street are used, and a crosswalk passes through the barrier, then the edges of the crosswalk should be constructed to be detectable to the visually impaired; and these crosswalk definition lines should lead to the edges of the barrier or, at least, end at points within the opening in the barrier.

the priority accessible network

From the analysis of the needs of the elderly and handicapped pedestrian described earlier, three types of pedestrian accessibility failure have been identified--a failure of elements, a failure of components, and system failure.

Element Failure. An element is an individual piece of the pedestrian system; i.e., a curb ramp, a stair, a bench, etc. Here, the failures are largely failures in design or maintenance. Sometimes, no accommodations are made for the elderly and the handicapped; no curb ramps are provided. And sometimes the accommodations are ill conceived, or work well for some of the handicapped or elderly while making things worse for others.

Component Failure. A component is a grouping of elements which forms one part of a system; i.e., a street crossing is a component, and it may consist of the following elements: curb ramps, signals, signs, walkway surfaces, etc. These failures are typically where some of the elements that make up the component have not been considered for accessibility. All of the effective elements of the component must be considered in the design even if the individual elements have been well conceived.

System Failure. A system failure is a general failure in any of the transportation systems of the city, including of course, the provisions for pedestrians. System failure is typically a failure of continuity. Whereas individual components (sidewalks, crosswalks, etc.) may be accessible, there are gaps in the system (e.g., an accessible sidewalk on one street has no corresponding accessible crosswalk leading to an adjoining street).

THE PRIORITY ACCESSIBLE NETWORK: A SOLUTION

The concept of a 'priority accessible network' is a response to the problem created by a non-systematic approach to the installation of countermeasures for the handicapped and elderly. It is based on the idea that the same planning principles of efficiency and effectiveness which underlie other types of transportation planning can be applied to the process of accommodating the needs of special populations. The goals of the network are as follows:

1. The sum of the measures implemented to improve accessibility (the network) must lead to an accessible system that is continuous and comprehensive in its service to all desired destinations.

2. The network must be inclusive of the needs of all handicapped groups. It should include provisions which are tailored to the needs of each of these groups, as well as provisions which relate to the population as a whole.

3. The network should be developed so that scarce resources are utilized in an orderly and effective manner, so that high priority routes are constructed before others with lesser importance, and so that the network is gradually expanded as money is made available.

The procedure for the achievement of these objectives is based on the idea of the 'priority accessible network' as both a physical concept and as a process.

THE PHYSICAL CONCEPT

The priority accessible network for any city consists of a number of fully accessible pedestrian routes connected together into a continuous system which is gradually expanded according to a plan. Each accessible route consists of a connected sequence of components formed from a connected sequence of elements. And each route is made accessible and added to the accessible system according to priorities set out in the plan. Each type of barrier along network routes would be removed by mandatory application of appropriate countermeasures.

THE DEVELOPMENT PROCESS

As a process, the priority accessible network may be defined as a phased allocation of resources over time, based on a determination of need and a commitment to system continuity. To achieve this, the following goals have been established:

1. The method selected for network design should be 'customized' in terms of the resources available to the city or local authority.

2. The 'development plan' should be structured so that it can be implemented incrementally over time.

3. The planning and implementation of the accessible network should involve the participation of all relevant interest groups.

The concept and details of the methodology for developing the Priority Accessible Network is described in "A Manual for Developing a Priority Accessible Network". The Manual has been organized into a sequence of decision-making steps beginning with problem identification, and ending with project implementation. The procedures described in each step are conventional, and reflect, as much as possible, currently used planning techniques. Alternative methods are presented where possible, to accommodate the varying needs and resources of the user.

Part One, "Network Planning Process," in The Planning Manual is a step-by-step description of the procedure for the planning of the accessible network, and in this manual:

> Section One--Organizing the Advisory Council describes the structure and constituency of the group which guides the planning process.
>
> Section Two--Planning the Accessible District focuses on the district as a planning unit and describes three alternative methods for collecting and analyzing data necessary to define and rank districts into the order in which they will be made accessible.
>
> Section Three--Planning the Accessible Route presents a method for breaking

down districts into their contituent routes, and for analyzing these routes in terms of the accessibility to the handicapped and elderly. Finally, the appropriate changes to make the routes accessible are listed.

Section Four—Formulating the Development Plan first presents ways by which the local government can measure its financial resources and can relate both existing and potential resources to its needs. Secondly, a procedure is described for the incorporation of individual barrier removal projects into a project package, and for the integration of this project package into the comprehensive development process.

Part Two, "Design Details," of the Manual is the Source Book, which will be used as a reference for recommended designs for the various elements of the system. The Source Book is laid out in a format that presents, on the left hand side of the page, major problems experienced by the elderly and handicapped pedestrian. On the right hand side of the page are the recommended solutions. Some of the problems and solutions are also illustrated in drawings and photographs.

The manual is intended for the use of all those who are interested in making cities and parts of cities accessible. It is not a research document, nor a technical report, but it incorporates the findings of the entire study.

FEDERALLY COORDINATED PROGRAM OF HIGHWAY RESEARCH AND DEVELOPMENT (FCP)

The Offices of Research and Development of the Federal Highway Administration are responsible for a broad program of research with resources including its own staff, contract programs, and a Federal-Aid program which is conducted by or through the State highway departments and which also finances the National Cooperative Highway Research Program managed by the Transportation Research Board. The Federally Coordinated Program of Highway Research and Development (FCP) is a carefully selected group of projects aimed at urgent, national problems, which concentrates these resources on these problems to obtain timely solutions. Virtually all of the available funds and staff resources are a part of the FCP, together with as much of the Federal-aid research funds of the States and the NCHRP resources as the States agree to devote to these projects.*

FCP Category Descriptions

1. Improved Highway Design and Operation for Safety

Safety R&D addresses problems connected with the responsibilities of the Federal Highway Administration under the Highway Safety Act and includes investigation of appropriate design standards, roadside hardware, signing, and physical and scientific data for the formulation of improved safety regulations.

2. Reduction of Traffic Congestion and Improved Operational Efficiency

Traffic R&D is concerned with increasing the operational efficiency of existing highways by advancing technology, by improving designs for existing as well as new facilities, and by keeping the demand-capacity relationship in better balance through traffic management techniques such as bus and carpool preferential treatment, motorist information, and rerouting of traffic.

3. Environmental Considerations in Highway Design, Location, Construction, and Operation

Environmental R&D is directed toward identifying and evaluating highway elements which affect the quality of the human environment. The ultimate goals are reduction of adverse highway and traffic impacts, and protection and enhancement of the environment.

4. Improved Materials Utilization and Durability

Materials R&D is concerned with expanding the knowledge of materials properties and technology to fully utilize available naturally occurring materials, to develop extender or substitute materials for materials in short supply, and to devise procedures for converting industrial and other wastes into useful highway products. These activities are all directed toward the common goals of lowering the cost of highway construction and extending the period of maintenance-free operation.

5. Improved Design to Reduce Costs, Extend Life Expectancy, and Insure Structural Safety

Structural R&D is concerned with furthering the latest technological advances in structural designs, fabrication processes, and construction techniques, to provide safe, efficient highways at reasonable cost.

6. Prototype Development and Implementation of Research

This category is concerned with developing and transferring research and technology into practice, or, as it has been commonly identified, "technology transfer."

7. Improved Technology for Highway Maintenance

Maintenance R&D objectives include the development and application of new technology to improve management, to augment the utilization of resources, and to increase operational efficiency and safety in the maintenance of highway facilities.

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* The complete 7-volume official statement of the FCP is available from the National Technical Information Service (NTIS), Springfield, Virginia 22161 (Order No. PB 242057, price $45 postpaid). Single copies of the introductory volume are obtainable without charge from Program Analysis (HRD-2), Offices of Research and Development, Federal Highway Administration, Washington, D.C. 20590.

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